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Comparative Advantage, Outward Foreign Direct Investment and Average Industry Productivity: Theory and Evidence

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This paper analyzes the role of comparative advantage in the effects of outward FDI on domestic productivity. In the theoretical framework, we place Helpman, Melitz and Yeaple's (2004) outward FDI model into Bernard, Redding and Schott's (2007) framework of international trade with heterogeneous monopolistically competitive firms and comparative advantage and show that the increase in outward FDI raises aggregate productivity in all industries through the intra-sectoral reallocation of firms, but this productivity growth is more prominent in a nation's comparative advantage industry. Using Korean industry-level data, we empirically test our theoretical predictions using the production function model as a benchmark model, followed by system GMM estimation methods for sensitivity analysis. Our empirical findings also suggest that outward FDI has a positive effect on domestic productivity and this link is more likely to take place in those sectors above average competitiveness measured as export-based revealed comparative advantage.

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I. Introduction

The rapid growth of activities of multinational firms in the past two decades[1] has

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[1] The World Investment Report published in UNCTAD (United Nations Conference on Trade and Development) in 2007 and 2010 show that the number of MNEs (multinational enterprises) in the world has grown from approximately 40,000 in 1993 with 270,000 foreign affiliates to about 103,786 MNEs with 892,114 foreign affiliates in 2010, and their exports account for about one third of world exports, including both goods and services.

triggered significant research into the impact of MNE (Multinational Enterprises) business activities on the domestic economy of the home country. One of the factors driving the recent wave of studies is the controversy over the effects of outward foreign direct investment (FDI) domestically. In many home countries where headquarters of MNEs are located, there exist widespread public concern on the potential negative effect of outward FDI on domestic output and employment when domestic activities are replaced by foreign operations, i.e., the 'Hollowing-out' (or 'Deindustrialization') phenomenon (Schnorbus and Giese, 1987; Spilimbergo, 1998; Simeon and Ikeda, 2003). An alternative perspective is that MNEs are able to expand their domestic capacities and employment by improving firms' profitability and competitiveness (Desai et al., 2009).

The empirical studies on this issue provide mixed results on domestic effects of outward FDI. The negative association between outward FDI and domestic performances due to the replacement of domestic investment by foreign investment is documented in Stevens and Lipsey (1992). Stevens and Lipsey (1992) address that outward FDI is a movement of production from home to foreign countries, rather than investment, and is considered as an opportunity cost for domestic investment. Bitzer and Görg (2005) also found that the effect of outward FDI on average productivity of 10 manufacturing industries in 17 OECD member countries between 1973 and 2000 was negative because domestic investment was replaced by foreign investment.

In contrast, other strands of literature find a complementary relationship between outward FDI and domestic activities (Lipsey et al., 2000; Becker and Muendler, 2008; Castellani and Navaretti, 2004; Masso et al., 2008). These studies argue that MNEs can improve their profitability and competitiveness by taking advantage of low factor costs of low-wage host countries and of tariff-jumping FDI. These conflicting empirical results suggest that the performance of outward FDI on productivity of domestic industry may be conditional. Accordingly, it is necessary to clearly identify the mechanism through which MNE's activities can affect domestic performances.

Theoretically, Helpman, Melitz and Yeaple (HMY hereafter, 2004) consider the intra-sectoral redistribution of factors from firms' global engagement, based on the Melitz's model (2003) which firstly develops the international trade model with firm heterogeneity under a monopolistic competitive market. HMY (2004) show that highly productive firms are more likely to perform outward FDI and enjoy higher profits, suggesting firm self-selection in serving foreign markets. Hence the increase in outward FDI implies that high productivity firms are more likely to actively engage in production in a domestic country as well as in foreign markets and in turn leads to growth in aggregate domestic productivity and employment vis-à-vis low productivity firms.

Meanwhile, recent theoretical works on the performance of globalization stress the role of both industry-level comparative advantage and firm-level productivity. By combining the endowment-based trade theory (i.e., the Heckscher-Ohlin model) and heterogeneous firm trade model (i.e., the Melitz's model), Bernard, Redding and Schott (BRS hereafter, 2007) show that the effects of trade liberalization on aggregate productivity will be more prominent in comparative advantage industries than in comparative disadvantage industries. In the former industries compared to the latter, trade liberalization creates more opportunity to export, leading to entry or growth of highly productive firms. These different performances across industries are due to various responses to trade liberalization by heterogeneous firms as well as industry characteristics.

While the previous studies which show the complementary relationship between outward FDI and domestic activities mainly focus on low variable costs in low-wage host countries and in tariff-jumping strategy by FDI, no research has ever been conducted to study the role of intra-sectoral redistribution of firms on this relationship. Also, while BRS (2007) is largely focused on the effects of international trade on domestic economy, studies investigating the role of comparative advantage of industries on multinationals' investment abroad, especially in the presence of heterogeneous firms under monopolistically competitive setting is very limited both theoretically and empirically. BRS (2007) analyze economic growth from performances of exporting firms in a domestic country, but abstract away outward FDI. Finally, HMY (2004) do not consider industry-level heterogeneity in analyzing the effects of outward FDI on aggregate domestic productivity by focusing on a single sector. To fill this gap, this paper contributes to the growing body of literature in this field by theoretically and empirically investigating the conditions under which outward FDI influences domestic productivity in a given industry through the intra-sectoral redistribution of firms. Especially, we explicitly address the role of comparative advantage in the effects of outward FDI on domestic productivity. In fact, we show that heterogeneous MNEs facing the same conditions in their home countries experience differences in performance in domestic operations according to competitiveness of their industries.

Our theoretical model builds on HMY's (2004) outward FDI model and BRS's (2007) framework of international trade with heterogeneous, monopolistically competitive firms and comparative advantage. Following HMY (2004), we place emphasis on firm self-selection in foreign markets in analyzing how outward FDI influence domestic industry productivity in the theoretical framework. HMY (2004) consider outward FDI in the condition on heterogeneous firms in monopolistically competitive environment, but ignore the role of competitiveness of industries. In addition, as BRS (2007) show that firm self-selection in foreign markets is diverse across industries with comparative advantage and disadvantage, we expect various impacts of outward FDI on domestic industry productivity, depending on different firm self-selection in foreign markets between industries with comparative advantage and disadvantage.

Our model explains why a country performs outward FDI more in a comparative advantage industry than in a comparative disadvantage industry even though both industries perform outward FDI. Also, we demonstrate that the increase in outward FDI can have different impact on aggregate productivity across both industries. Consequently, our theoretical framework shows that highly productive firms perform outward FDI and low productive firms serve only a domestic market, as in HMY (2004). Second, the share of MNEs are relatively greater in a comparative advantage industry than in a comparative disadvantage industry so that the *ex ante* aggregate productivity in the former is relatively greater than that in the latter. Finally, we show that the increase in outward FDI raises aggregate productivity in both industries through the intra-sectoral reallocation of firms and this phenomenon occurs more prominently in a country's comparative advantage industries.

We also empirically test our theoretical predictions using Korean industry-level data from 1992 to 2008. The various studies on the relationship between outward FDI and its effects on domestic operations lack empirical investigation on the conditions under which the effects are accentuated or ameliorated. Our empirical findings suggest that outward FDI positively affects domestic productivity and this link is more likely to take place in those sectors with competitiveness. These empirical findings are consistent with previous theoretical predictions as well as our theoretical hypotheses.

The paper is organized as follows. Section 2 provides a simple theoretical model built upon HMY (2004) and BRS (2007) to highlight that outward FDI tends to have a positive impact on productivity, especially, within an industry which possesses comparative advantage. Section 3 and 4 explain the dataset of Korean multinational activities by industry and present empirical results regarding the effect of outward FDI on domestic productivity and the role of industry competitiveness. Section 5 summarizes the findings and concludes with a future research agenda.

II. Model

In this chapter we develop the theoretical model which lays the foundations for empirical results in the following section. The feature of the basic setup is similar to BRS (2007). We, however, expand BRS (2007) into the topic on multinationals by introducing outward FDI as a firm's global engagement into the model. Also, we incorporate sector heterogeneity with comparative advantage and disadvantage into HMY (2004). Finally, we additionally introduce intra-firm trade into FDI to be consistent with the facts that MNEs generally perform FDI and exports simultaneously and the relationship between them is complementary[2].

2.1. Demand

We assume that there are two countries, home (H) and foreign (F); two industries, 1 and 2; and two production factors, skilled labor and unskilled labor. There are no other production factors besides skilled-and unskilled-labor in the model. Both countries are symmetric in every respect, except that the home country is abundant with skilled labor, while the foreign country is unskilled labor-abundant. Similarly, both industries are symmetric in every respect, except that industry 1 is skilled labor-intensive, while industry 2 is unskilled labor-intensive. According to the Heckscher-Ohlin (HO) theory[3], the home country has comparative advantage in industry 1, while the foreign country has comparative advantage in industry 2. Hence there are several differences in the nature of industries across countries, depending on the existence of comparative advantage.

Each country is endowed with $\bar{S}$ units of skilled labor and $\bar{U}$ units of unskilled labor with the wage level, w_S and w_U, respectively; and income I. By the labor market clearing condition, $S_1 + S_2 = \bar{S}$ and $U_1 + U_2 = \bar{U}$ for each country, and labor cannot move across countries. By the assumption on the relative factor abundance of countries, $\frac{S^H}{U^H} > \frac{S^F}{U^F}$. Each industry is populated by homogeneous consumers and heterogeneous firms. Consumption between two industries represents a Cobb-Douglas, i.e., $U = C_1^{\alpha_1} C_2^{\alpha_2}$, where α_i is the expenditure share to industry i, ($i = 1$ *or* 2) and $\alpha_1 + \alpha_2 = 1$. As we assume that a country's comparative advantage comes only from the production side, not from the demand side, α_i is assumed to be the same for each sector in each country, i.e., $\alpha_1 = \alpha_2 = \alpha$ for each country. In each sector a representative consumer has CES preferences over a continuum of differentiated goods indexed by x. A consumer's maximization problem is[4]:

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[2] Neary (2009) shows that both horizontal FDI and trade grow when trade costs fall in the 1990s, which seems to be contradictory to HMY (2004). Neary (2009) emphasizes the importance of intra-firm trade as possible resolution to this paradox (Also see Mukherjee and Suetrong 2012). As our dataset shows that MNEs do not produce all products in foreign affiliates and the correlation between FDI and exports is positive (see Appendix II), we input intra-firm export in considering FDI. Also see Kim and Kang (1997) and Bae and Jang (2013) for the empirical evidences of the complement relationship between export and FDI in Korea.

[3] The HO theorem addresses that a country will have comparative advantage in that good whose production is relatively intensive in the factor with which that country is relatively well endowed. In a open economy, a country specializes in producing its comparative advantage goods and exports them (Husted and Melvin, 2013, p.94).

[4] As each country represents the same type of utility function, we omit the country superscript, i.e., *H* or *F*, in this subsection.

$$\max_{q(x)} C_i = \left[\int_{x \in X} q_i(x)^{\rho} dx \right]^{\frac{1}{\rho}}, \quad 0 < \rho < 1 \tag{1}$$

$$s.t. \int_{x \in X} p_i(x) q_i(x) dx = \alpha I \tag{2}$$

where C_i is a consumption index, $q_i(x)$ is the demand for x, $p_i(x)$ is the price of x, X is the set of goods and ρ is the elasticity of substitution across goods with $\rho = \frac{\sigma - 1}{\sigma}$ and $\sigma > 1$. As represented in (1), ρ does not have the subscript i, implying that each country has the same elasticity of substitution across sectors.

Then the consumer maximization problem induces the demand function as follows:

$$q_i(x) = \alpha I P_i^{\sigma-1} p_i(x)^{-\sigma} \tag{3}$$

where P_i is the aggregate price index which is the indirect utility of the CES function. i.e.,

$$P_i = \left[\int_{x \in X} p_i(x)^{1-\sigma} dx \right]^{\frac{1}{1-\sigma}} \tag{4}$$

2.2. Production

We assume that in a monopolistically competitive market each one of X firms produces a single differentiated variety x. Production represents increasing returns technology and involves both variable and fixed costs. Each firm has different fixed and variable costs, depending on its heterogeneous productivity and selection into markets. In addition, based on the Hechsher-Ohlin theorem, each industry in each country has different wage rates: the relative wage rate of skilled labor in the home country is lower than that in the foreign country, i.e., $\frac{w_S^H}{w_U^H} < \frac{w_S^F}{w_U^F}$, as the home (foreign) country is skilled (unskilled) labor-abundant and then a larger relative supply of skilled (unskilled) labor leads to its lower relative wage.[5]

In this respect, the marginal cost (*MC*) for selection into each market is as follows:

[5] There are two definitions of resource abundance: quantity definition, $\frac{S^H}{U^H} > \frac{S^F}{U^F}$, and price definition, $\frac{w_S^H}{w_U^H} < \frac{w_S^F}{w_U^F}$ (Husted and Melvin, 2013, p. 93).

- Domestic production: $MC_{iD}^{H}=\frac{1}{\theta}(w_{S}^{H})^{\beta_i}(w_{U}^{H})^{1-\beta_i}$ (5)

- Overseas production: $MC_{iO}^{H}=\frac{1}{\theta}(\tau(w_{S}^{H})^{\beta_i}(w_{U}^{H})^{1-\beta_i})^{1-\varphi}((w_{S}^{F})^{\beta_i}(w_{U}^{F})^{1-\beta_i})^{\varphi}$ (6)

where $1>\beta_1>\beta_2>0$ as 1 is skill-intensive, and D and O denote domestic production and overseas production , respectively. $\tau>1$ is a per-unit iceberg cost for exporting, φ is the fixed ratio of affiliate labor expenditure to total variable costs ($0\le\varphi\le 1$), and $\theta\ge 1$ is the firm's heterogeneous productivity, which is exogenously drawn from a Pareto distribution with the function:

$$F(\theta)=1-\theta^{-\gamma},\ \lambda=\gamma-(\sigma-1)>0 \quad (7)$$

where γ is the Pareto index which represents the measure of quality dispersion. Considering a MNE serves domestic consumers as well as abroad activity, (6) represent additional marginal costs of production in foreign country.

In global engagement a firm can choose either exports or FDI or possibly both. φ in (6) represents this figure: to enter the foreign market, a firm performs only exporting with $\varphi=0$ (i.e., pure exporter), while only FDI with $\varphi=1$ (i.e., pure investor). With the overseas production function with φ in (6), the difference between our model and HMY (2004) is that we rule out the situation where both pure exporters and pure investors exist simultaneously in an industry. In other words, we have three cases in a firm's global engagement: only pure exporters with $\varphi=0$ or only pure investors with $\varphi=1$ or MNEs which export and perform FDI simultaneously with $0<\varphi<1$.[6]

The main reasons for this are as follows: first, the main objective of the paper is to analyze how differently outward FDI affects industry-level productivity across comparative advantage and comparative disadvantage industries in home country. In other words, all other things being equal, we tried to examine the "direct" effects of the increase in outward FDI on domestic productivity both theoretically and empirically. As long as we do not analyze any effects of trade liberalization like what HMY (2004) did, the existence of pure exporters does not play any role in the model. Rather, the existence of pure exporters will distract the main objective of the paper. This distraction is mainly related to the question whether export and FDI are substitutes or complements: the increase in outward FDI will also affect pure exporters' performances and thus affect productivity 'indirectly' under the situation where both pure exporters and pure investors exist. Hence, these indirect effects of the increase in outward FDI via the mechanism of change in pure

[6] Accordingly, The model reverts to Bernard, et al. (2007)'s when $\varphi=0$, while it becomes similar to HMY (2004)'s when $\varphi=1$.

exporters'performance will depend on how exports and FDI are related. However, the relationship between an export of a final good and FDI can be either substitute or complement, noting that many empirical studies have found the mixed results on it.[7] This indefinite relationship between an export of a final good and FDI would distract from our focus on the relationship among FDI, heterogeneous firms, and comparative advantages. In addition, since our FDI data set do not distinguish between horizontal FDI and vertical FDI, we cannot empirically examine the role of FDI in domestic performances to capture its relationship with exports. Therefore, it will be beyond our capacity to take two types of FDI into account in the theoretical framework.

More generally, for the total production performed by MNE, $0<\varphi<1$ represents that a firm produces φ portion in foreign country, and also $(1-\varphi)$ portion in home and then exports it to foreign country. There are three reasons why MNEs still have production activities in home country when performing FDI in foreign country. First, MNEs build plants in foreign countries but do not usually produce all final products there. They still export some products to foreign consumers while paying τ because specific technologies required for those products are only available in a domestic country. According to export-import bank of Korea in 2008, 49.7% of Korean multinationals sell their products in host country via FDI and export to the same host country simultaneously.

Second, the parent firm in the home country exports the intermediate product to the affiliate in a foreign country while paying the variable exporting cost, τ. Then the affiliate produces the final good by assembling the parts of the good with local labor (Irarrazabal et al., 2009). For Korea Kim et al. (2011) show that the portion of intermediates in total exports is about 50% in 2009, and is becoming more important to the national economy. Particularly, the second reason can be equally applied to both types of FDI, horizontal and vertical ones.[8] Finally, our dataset shows that MNEs generally perform FDI and exports simultaneously and the correlation between outward FDI and export is positive (see Appendix II).

The firm's profit function in country k is:

$$\pi_{ih}^{k}=p_{ih}^{k}q_{ih}^{k}-MC_{ih}^{k}q_{ih}^{k}-f_{h},\ i=1 \text{ or } 2,\ h=D \text{ or } O\quad k=H\ or\ F \tag{8}$$

[7] Theoretically, trade substitutes for horizontal FDI, while complementing to vertical FDI (Markusen and Venables, 1998; Helpman et al., 2004). However, the empirical studies conclude that the relationship is ambiguous, depending on parent and host country's characteristics, FDI and export types and sector's properties (Brainard, 1997a, 1997b; Head and Ries, 2004; Greenaway and Kneller, 2007; Jang, 2011).

[8] The empirical evidences of the positive relationship between exports and FDI can be found in Lipsey and Weiss (1984) for the U.S. and Svensson (1996) for Sweden. For the complement relationship between exports and FDI in Korea, see Kim and Kang (1997), and Bae and Jang (2013).

where the subscript i, h, and k denotes an industry, a selection mode into markets and a country, respectively. f_h is the fixed cost for each production mode. τ and f_h is assumed to be same for each industry in each country. Finally, we hold the following condition for the ordering of thresholds of firm productivity in Session 2.4:

$$\frac{1}{\tau^{(\sigma-1)(1-\varphi)}}\left(\frac{P_i^F}{P_i^H}\right)^{\sigma-1}\left(\frac{(w_S^H)^{\beta_i}(w_U^H)^{1-\beta_i}}{(w_S^F)^{\beta_i}(w_U^F)^{1-\beta_i}}\right)^{\varphi(\sigma-1)} f_D < f_O \tag{9}$$

2.3. Equilibrium

A firm's profit maximization yields the equilibrium price of each production mode in the home country:

- Domestic production: $$p_{iD}^H = \frac{1}{\theta\rho}(w_S^H)^{\beta_i}(w_U^H)^{1-\beta_i} \tag{10}$$

- Overseas production: $$p_{iO}^H = \frac{1}{\theta\rho}(\tau(w_S^H)^{\beta_i}(w_U^H)^{1-\beta_i})^{1-\varphi}((w_S^F)^{\beta_i}(w_U^F)^{1-\beta_i})^{\varphi} \tag{11}$$

where $\frac{1}{\rho}$ represents a firm's mark-up. Hence each equilibrium price comprises a firm's mark-up and marginal cost of each production mode.

Substitute (3) into (10) and (11) to obtain the equilibrium output of each production mode in the home country:

- Domestic production: $$q_{iD}^H = \alpha I^H (P_i^H)^{\sigma-1}\left(\frac{\theta\rho}{(w_S^H)^{\beta_i}(w_U^H)^{1-\beta_i}}\right)^{\sigma} \tag{12}$$

- Overseas production: $$q_{iO}^H = \alpha I^F (P_i^F)^{\sigma-1}\left(\frac{\theta\rho}{(\tau(w_S^H)^{\beta_i}(w_U^H)^{1-\beta_i})^{1-\varphi}((w_S^F)^{\beta_i}(w_U^F)^{1-\beta_i})^{\varphi}}\right)^{\sigma} \tag{13}$$

Then the equilibrium revenue of each production mode in the home country is:

- Domestic production: $$r_{iD}^H = \alpha I^H\left(\frac{P_i^H\theta\rho}{(w_S^H)^{\beta_i}(w_U^H)^{1-\beta_i}}\right)^{\sigma-1} \tag{14}$$

- Overseas production: $$r_{iO}^H = \alpha I^F\left(\frac{P_i^F\theta\rho}{(\tau(w_S^H)^{\beta_i}(w_U^H)^{1-\beta_i})^{1-\varphi}((w_S^F)^{\beta_i}(w_U^F)^{1-\beta_i})^{\varphi}}\right)^{\sigma-1} \tag{15}$$

Other things being equal, r_{iO}^H is decreasing in τ and r_{iD}^H is increasing in P_i^H.

From (8) and (10)-(15) the equilibrium profit of each production mode in each country can be written as $\pi_{ih}^{k} = \frac{r_{ih}^{k}}{\sigma} - f_h$. Hence total profits, π_i^k, for the domestic producer and MNE are

$$\pi_i^k = \begin{cases} \pi_{iD}^k & \text{if it does not perform FDI} \\ \pi_{iD}^k + \pi_{iO}^k & \text{if it performs FDI} \end{cases} \tag{16}$$

The second term in (16) implies that every multinational firm serves its domestic market as well as a foreign market. Our dataset also represents that all MNEs sale in their home market, that is Korea.

2.4. Thresholds of Firm Productivity

There exist two thresholds of firm productivity in each production mode such that $\pi_{iD}^k = 0$ and $\pi_{iO}^k = 0$, respectively, i.e., zero-profit productivity cut-offs. In the home country the productivity cut-offs for a domestic producer and for a MNE, respectively, are:[9][10]

$$\text{- Domestic production: } \quad \overline{\theta}_{iD}^{H} = \delta \frac{1}{P_i^H (\alpha I^H)^{\frac{1}{\sigma-1}}} f_D^{\frac{1}{\sigma-1}} (w_S^H)^{\beta_i} (w_U^H)^{1-\beta_i} \tag{17}$$

$$\text{- Overseas production: } \quad \overline{\theta}_{iO}^{H} = \delta \frac{1}{P_i^F (\alpha I^F)^{\frac{1}{\sigma-1}}} f_O^{\frac{1}{\sigma-1}} (\tau (w_S^H)^{\beta_i} (w_U^H)^{1-\beta_i})^{1-\varphi} ((w_S^F)^{\beta_i} (w_U^F)^{1-\beta_i})^{\varphi} \tag{18}$$

where $\delta = \frac{\sigma^{\frac{\sigma}{\sigma-1}}}{\sigma-1}$ represents the composition of market competition. Other things being equal, $\overline{\theta}_{iO}^{H}$ is increasing in FDI barriers such as f_O and τ. Also, $\overline{\theta}_{iD}^{H}$ is decreasing in the average price level of industry, P_i^H, while $\overline{\theta}_{iO}^{H}$ does not depend on it.

The condition in (9) ensures the ordering of these thresholds such as $0 < \overline{\theta}_{iD}^{H} < \overline{\theta}_{iO}^{H}$, conforming selection into markets in the model. After discovering its productivity, if a firm's productivity is less than $\overline{\theta}_{iD}^{H}$, then it will exit the market due to $\pi_{iD}^H < 0$. On the other hand, a firm will operate in the domestic market if its productivity is greater than or equal to $\overline{\theta}_{iD}^{H}$, due to $\pi_{iD}^H \geq 0$. Similarly, if a firm productivity is greater than or equal to $\overline{\theta}_{iO}^{H}$, then it will export and/or perform FDI to serve the foreign market due to $\pi_{iO}^H \geq 0$, serving the domestic market simultaneously. Note that the increase in $\overline{\theta}_{iD}^{H}$ (or $\overline{\theta}_{iO}^{H}$) implies that more firms

[9] Similarly, we can also obtain two thresholds for the foreign country, $\overline{\theta}_{iD}^{F}$ and $\overline{\theta}_{iO}^{F}$.

[10] Hereafter, we denote domestic firms (or producers) as those serve only the domestic market and MNEs as those do business in both the domestic and foreign markets.

exit the domestic market (or the foreign market).

2.5. Industry-Level Aggregation

As we are using industry-level data in the following empirical part, we introduce several industry-level aggregated variables for analysis. Based on the cut-off levels of firm productivity, we rewrite the average price index of sector i in home country as follows:

$$P_i^H = \left(\int_{\bar{\theta}_{iD}^H}^{\infty} (p_{iD}^H)^{1-\sigma} dF(\theta) + \int_{\bar{\theta}_{iO}^H}^{\infty} (p_{iO}^H)^{1-\sigma} dF(\theta) \right)^{\frac{1}{1-\sigma}} \tag{19}$$

Then, substitute (10), (11), (17) and (18) into (19) to obtain,

$$P_i^H = \Omega (w_S^H)^{\beta_i} (w_U^H)^{1-\beta_i} \left(\left(\frac{1}{f_D} \right)^{\frac{\lambda}{\sigma-1}} + \left(\frac{1}{f_O} \right)^{\frac{\lambda}{\sigma-1}} \frac{1}{\tau^{\gamma(1-\varphi)}} \left(\frac{(w_S^H)^{\beta_i} (w_U^H)^{1-\beta_i}}{(w_S^F)^{\beta_i} (w_U^F)^{1-\beta_i}} \right)^{\gamma\varphi} \left(\frac{P_i^F}{P_i^H} \right)^{\lambda} \right)^{-\frac{1}{\gamma}} \tag{20}$$

where $\lambda = \gamma - (\sigma - 1)$ and $\Omega = (\frac{\sigma}{\alpha I})^{\frac{\lambda}{\gamma(\sigma-1)}} \frac{\lambda}{\gamma}^{\frac{1}{\gamma}} \frac{1}{\rho}$.

Finally, as in Melitz (2003)[11], we define the average productivity as follows:

$$\tilde{\theta}_i^H = \left(((w_S^H)^{\beta_i} (w_U^H)^{1-\beta_i})^{1-\sigma} \int_{\bar{\theta}_{iD}^H}^{\infty} \theta^{\sigma-1} dF(\theta) \right.$$
$$\left. + \left((\tau (w_S^H)^{\beta_i} (w_U^H)^{1-\beta_i})^{1-\varphi} ((w_S^F)^{\beta_i} (w_U^F)^{1-\beta_i})^{\varphi} \right)^{(1-\sigma)} \int_{\bar{\theta}_{iO}^H}^{\infty} \theta^{\sigma-1} dF(\theta) \right)^{\frac{1}{\sigma-1}} \tag{21}$$

From (20) and (21), then we obtain

$$\tilde{\theta}_i^H = \frac{1}{\rho P_i^H} \tag{22}$$

For given market competition ρ, the average productivity of sector i is decreasing in its average price level.

[11] Also see Baldwin and Robert-Nicoud (2004) and Meckl and Weigert (2011) for the definition of average industry productivity.

2.6. Outward FDI, Aggregate Productivity and Comparative Advantage

In this section we show how average industry productivity interacts with outward FDI, which vary across industries and countries, by developing the effects of opening a closed economy to costly overseas production.

Proposition 1: The increase in outward FDI raises average industry productivity in both industries.

Proof. See Appendix **I**.

As the economy moves to free FDI situation, removing FDI barriers such as f_O, only a subset of firms which are relatively more productive have more chance to perform FDI, and their *ex post* profits rise, which can be expressed by the decrease in $\overline{\theta}_{iO}^{k}$ in (18). As highly productive (or more efficient) firms with lower marginal costs tend to produce more in the economy, the average price level which reflects average production cost falls. In other words, the average price can be lower by producing some in a foreign market (i.e., performing FDI), compared to producing all in a domestic market, which is expressed by $(P_i^H)^{FREE\ FDI} < (P_i^H)^{COSTLY\ FDI} < (P_i^H)^{CLOSED\ ECON}$ in the proof of Proposition 1. The decrease in P_i^H pulls domestic firms' revenue down as r_{iD}^H is increasing in P_i^H in (14), and their *ex post* profits fall. Hence, a subset of firms which are relatively less productive serving only the domestic market cannot maintain their revenues to cover f_D any more and exit the market, which can be expressed by the increase in $\overline{\theta}_{iD}^{k}$ in (17). Finally, as firms with low productivity exit the market, the average productivity in the industry rises in (22).[12]

Consequently, in response to the increase in the opportunity to perform outward FDI, relatively more productive firms can expand their production at the expense of relatively less productive firms under the resource constraint. In turn, this process carries out industrial restructuring through reallocation of firms. Hence, the expansion of MNE with high productivity and the exit of domestic firms with low productivity jointly induce aggregate productivity growth of an industry.[13]

Proposition 2: Other things being equal, the increase in average industry productivity is larger in a country's comparative advantage industry than in a country's disadvantage industry inresponse to the increase in outward FDI in each sector.

[12] Noting that the model in this paper is a static version of a Melitz-type model.

[13] BRS (2007) call these processes as the creative destruction of firms. Here we differently show the creative destruction of firms by the expansion of opportunity for outward FDI, while BRS (2007) do it by that for exports.

Proof. See Appendix **I**.

The result in $\frac{\bar{\theta}_{1D}^{H}}{\bar{\theta}_{1O}^{H}} > \frac{\bar{\theta}_{2D}^{H}}{\bar{\theta}_{2O}^{H}}$ in the proof of Proposition 2 shows that the threshold for FDI is relatively closer to that for only domestic production in a comparative advantage industry than in a comparative disadvantage industry in a home country. This implies that there are relatively greater FDIs from a comparative advantage industry than from a comparative disadvantage industry in a home country, (i.e., $\frac{\bar{\theta}_{1O}^{H}}{\bar{\theta}_{1D}^{H}} < \frac{\bar{\theta}_{2O}^{H}}{\bar{\theta}_{2D}^{H}}$), which is consistent with our empirical results in the following chapter (see Table 2 and 3).

Given that relative profits from FDI to those from only domestic production is larger in comparative advantage industry, the *ex post* profits of MNEs with highly productive firms increase more in comparative advantage industry in response to the increase in FDI. According to Proposition 1, domestic firms with low productivity are more likely to be forced to exit the market in comparative advantage industry. As a result, the growth in average industry productivity is more prominent in comparative advantage industry following the increase in FDI. Proposition 2 shows that the creative destruction of firms induced by the expansion of outward FDI is relatively more pronounced in a comparative advantage industry than in a comparative disadvantage one. This implies that the effects of the increase in outward FDI on the average productivity growth are stronger in the former.

In the next section, we empirically test two hypotheses which we developed in this section. In particular, we mainly estimate the effects of outward FDI on industry's aggregate productivity and compare them across its main characteristics, i.e., comparative advantage, focusing on Proposition 1 and 2. In generating process in Proposition 1 and 2 and applying it to the case of Korea, four empirical evidences are relevant. The first one is the relationship between comparative advantage and skill-intensity in industries. Choi and Lee (2010) empirically show that the revealed comparative advantage index (RCA) for Korea is relatively high in technology-intensive industries. The second one is whether the relative wage or the employment for skilled labor rises after the increase in FDI in Korea. Hyun et al. (2010) empirically show that outward FDI increases the domestic employment for white-collar workers in Korea, and these effects are more prominent in the long run. Also our empirical tests in Appendix IV show the positive relationship between FDI and wages. These evidences ensure that outward FDI affects sectoral redistribution of production factors and thus industrial structure improvement in Korea. The third one is whether intermediate exports are more prominent in comparative advantage industries in Korea. Choi and Lee (2010) and Kim et al. (2011) empirically show that intermediate exports are positively correlated with industries with high value of RCA in Korea. The final one is whether there are more MNEs in comparative advantage industries in Korea. For this, Table 1, 2 and 3 in the paper show the positive correlation between RCA and FDI. Hence these four evidences support the proof of Proposition 2 and allow our empirical analysis for the case of Korea in the following section.

III. Empirical Strategy and Data

3.1. Empirical Strategy

To empirically test the hypotheses derived in section 2, we estimate the impact of outward FDI on productivity and the role of RCA as a potential channel through which outward FDI can affect productivity. To build an empirical strategy, we take several steps. First, to test Proposition 1, using the panel dataset and controlling industry and year fixed effects, we examine whether outward FDI has any impact on productivity. Second, by interacting FDI and RCA dummy variables we test the validity of Proposition 2 on whether the effect of FDI on productivity can vary depending on sectoral comparative advantage. Lastly, we employ system GMM (Generalized Method of Moments) for robustness check to confirm the empirical test results of the baseline model.

3.1.1. Measurement of Productivity and Baseline Model

To measure industry productivity we use total factor productivity (TFP). We derive regression based measure of industry-level TFP in the form of Cobb-Douglas production function. The production function is given in (23).

$$\ln Y_{it} = c + \beta_0 lnA_{it} + \beta_1 lnK_{it} + \beta_2 lnL_{it} + \mu_t + u_{it} \tag{23}$$

where Y, K, L is real value added per labor, real capital per labor and labor respectively. A_{it} represents TFP of industry i at time t and measured as the residual of the regression of the natural logarithm of real value added per labor on the logarithm of real capital stock per labor and the logarithm of the number of workers for each industry. The real value added is computed as real output less real intermediate input which is sum of costs on raw materials, energy, and services. One of advantage of using the value added concept for productivity is that it avoids double counting of intermediate inputs (Diewert, 2000). The real output is measured as total sales at each industry deflated using Producer Price Index (PPI) from Bank of Korea (BOK). Intermediate input cost is deflated using industry level price deflators based on real price collected from Korea Industrial Productivity Database (KIP) 2011. The real capital stock is computed as sum of real stock of building, machine, and transportation at industry level using KIP Database. Since we have no information on working hours at industry level, we use number of workers as a proxy for labor. μ_t and u_{it} represent the year dummies and the error term, respectively.

Based on the estimation of productivity in (23), we derive our baseline model as follows:

$$lnA_{it} = \delta_0 + \delta_1 lnFDI_{it-1} + \delta_2 lnRCA_{it-1} + \delta_3 lnFDI_{it-1} \times RCA_{it-1} + \rho_t + \theta_i + \varepsilon_{it} \quad (24)$$

where FDI_{it-1} is the lagged value (thousands of US dollars) of outward foreign direct investment in industry *i* at time *t*. RCA_{it-1} is the lagged RCA index or dummy variable taking the value one if the value of RCA of industry *i* is above median or mean of all industries in each year and zero, otherwise. An alternative way of measuring RCA_{it-1} is to use an RCA dummy variable which takes value one if RCA index of a specific industry is greater than one and takes zero, otherwise. The empirical results using all four measurements are reported. ρ_t is year specific effect observing macroeconomic shocks common to all industries. θ_i is industry fixed effect to control for unobserved heterogeneity in the determinants of industry specific productivity.

If our theoretical prediction that the increase in outward FDI raises average productivity regardless of industry competitiveness holds, δ_1, the coefficient of lagged FDI is expected to be positive and statistically significant. One can expect that a higher comparative advantage results in a higher TFP independent of FDI. Thus, RCA is included as a single regressor. The sectoral difference in FDI-TFP linkage can be tested by the direction of the coefficient of lagged interaction term between FDI and RCA.

3.1.2. Endogeneity Issue

When estimating equation (24), it can be argued that industries with higher productivity are more likely to invest abroad. To control for this potential endogeneity problem and to confirm the result, we estimated augmented baseline specification model using system GMM estimation suggested by Arellano and Bover (1995), Blundell and Bond (1997) and Blundell et al. (2000). By eliminating time invariant variables omitted variable bias can be controlled. However, the dynamic panel bias remains (Nickell, 1981; Bond, 2002) as well as the endogeneity problem. The introduction of system GMM can alleviate this problem by resolving the endogeneity problem and by yielding a consistent estimator. To propose a system GMM, however, error terms should be independent and valid instruments should be chosen. Under the assumption of no correlation between first-differences and industry-specific effects, the basic methodology of system GMM is to combine both equations in first-differences, using the lagged level variables as instruments, with equations in levels with lagged first-differences as instruments.

To check the validity of instrumental variables, two specification tests are implemented. The first test is to examine whether there is a serial correlation between error terms in a first-differenced equation. By the nature of construction, the difference errors may be first-order serially correlated (Carkovic and Levine, 2002) and negative first-order serial correlation is expected in differences. Thus, to check for first-order serial correlation, we further look for second-order correlation in differences, based on the idea that this will detect correlation between the lagged error term in differenced error term and the error term lagged two periods in lagged differenced error term. The second test is the Hansen test, in which the null signified that there is no over-identifying restrictions problem.

3.2. Data

This paper relies on three different merged datasets of 52 Korean mining and manufacturing industries over 17-year period from 1992 to 2008. First, the data for outward FDI was drawn from the Korea EXIM bank (Export-Import Bank of Korea). Industries are classified based on KSIC (Korea Standard Industry Code) Rev. 6. Since, however, the EXIM bank dataset does not provide detailed information on industry characteristics such as capital, employment, value added, and exports, we need to merge it with secondary datasets containing information on industry attributes over time to capture the effects of industry characteristics on productivity. We built a dataset that includes information on the number of employment, value added, and capital stock collected from the '*Survey of mining and manufacturing*' conducted by the National Statistical Office of Korea.[14] Third, the index of comparative advantage of an industry is measured as RCA. Based on the argument in Section 2.2 on the complementarity between exporting and FDI,[15] RCA is measured as

$$RCA_{iX}^{Kor} = \left(q_{iX}^{Korea} \Big/ \sum q_{iX}^{Korea} \right) / \left(q_{iX}^{World} \Big/ \sum q_{iX}^{World} \right) \tag{25}$$

[14] EXIM bank dataset provides information on FDI destination by industry, but this information is not available in NSO datasets. Thus, we fail to identify host countries of outward FDI at a certain industry.

[15] In the theoretical framework, RCA in (25) can be written by $\left(Q_1^H \big/ Q_1^H + Q_2^H \right) / \left(Q_1^F \big/ Q_1^F + Q_2^F \right)$ and should be greater than 1. From (21) and (22), $\left(\tilde{\theta}_1^H \big/ \tilde{\theta}_1^H + \tilde{\theta}_2^H \right) / \left(\tilde{\theta}_1^F \big/ \tilde{\theta}_1^F + \tilde{\theta}_2^F \right) = \left(P_2^H \big/ P_1^H + P_2^H \right) / \left(P_2^F \big/ P_1^F + P \right) > 1$ as $\frac{P_1^H}{P_2^H} < \frac{P_1^F}{P_2^F}$. Similarly, we can derive the condition for $\left(Q_1^H \big/ Q_1^H + Q_2^H \right) / \left(Q_1^F \big/ Q_1^F + Q_2^F \right) < 1$ if $\frac{P_1^H}{P_2^H} < \frac{P_1^F}{P_2^F}$ holds. As the aggregate quantity, Q_i^k, is increasing in the average productivity, $\tilde{\theta}_i^k$, we conclude that RCA is greater than 1 for a comparative advantage industry.

where q_{iX} denotes value of export at industry i. The export data is obtained from the United Nations Commodity Trade Statistics Database (UN COMTRADE). Table 1 shows the summary statistics of data used in our empirical studies. The industry characteristics such as TFP, RCA index, and outward FDI are reported in Appendix III. Table 1 and Appendix IIrespectively provide descriptive statistics and correlation matrix for key variables in our study. The correlation matrix does not show any symptoms of multicollinearity.

[Table1] Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
FDI	771	69291.77	159865.7	0	1800000
RCA index	849	0.993	1.350	0	10.619
RCA median dummy	867	0.529	0.499	0	1
RCA mean dummy	867	0.322	0.467	0	1
RCA index dummy	867	0.341	0.474	0	1
Real Value Added	847	4416603	6256216	-14727	5.30E+07
lnTFP	798	-4E-08	0.1486972	-0.652	0.7743607
Real Capital	847	3610854	6031476	964	5.91E+07
Labor	798	53725.36	59565.34	24	352556

Note: RCA median and mean dummies indicate whether the RCA index of a specific industry is above or below median, mean of whole industries in a certain year. RCA index dummy indicates whether RCA index of an industry exceeds 1 or not. Natural log of TFP is residual of regression of the log of real capital per labor, labor on the log of real value added per labor. The unit of value added, capital and FDI is 1,000 USD.

IV. Empirical Results

In the following section, we begin with investigating empirically the effect of outward FDI on productivity and also the role of comparative advantage. As with other policy variables, lags are expected between outward FDI and its impact on productivity of domestic industries. Thus, we test for the effects of lagged values of outward FDI and its interaction with RCA of each industry.

4.1. Comparative Advantage, Outward FDI and Productivity

In this section, we investigated the role of comparative advantage in the effect of FDI on productivity measured as TFP. The results are shown in Table 2. Column (1) of Table 2 contains the estimates of the effect of outward FDI on productivity. Column (3) presents the result of the regression analysis for the role of industry comparative advantage when RCA index is used as measurement of comparative advantage of each industry. Column (4) of Table 2 report the estimates when the

RCA dummy variable is measured as a binomial variable taking one if RCA index exceeds industry median of the year and zero, otherwise. Column (5) of Table 2 contain estimates when RCA dummy is created according to relative magnitude of RCA index of a certain industry to mean value, while Column (6) reports estimation result when RCA is measured as index dummy which is "one" when RCA index of an industry is greater than one and zero, otherwise. To avoid simultaneity problem among variables, interaction terms between outward FDI and RCA proxy are mean centered. All specifications of the regression of Table 2 include both year and industry fixed effects.

Column (1) of Table 2 shows that RCA index is positively associated with industry productivity. The results in column (2) show that the coefficient of outward FDI and the coefficient of RCA index are positive and statistically significant, suggesting that lagged outward FDI has positive effects on industry-level TFP. The coefficient estimates of the effect of FDI on industry productivity in column (3) through (6) are also statistically significant and positive. More specifically, these results suggest that a 1 percentage point increase in the outward FDI in an industry raises productivity by 0.001∼0.002 percentage. The magnitude of the impact of FDI is not directly comparable with previous literature as most of the related works did not consider the role of comparative advantage in their empirical tests.[16] These results support Proposition 1 in that the increase in outward FDI contributes to raising productivity in industries on average.[17] As for the interaction terms of the lagged outward FDI and the sectoral competitiveness reported in Column (3) of Table 2, we find that the coefficients on the impact of RCA variable on the relationship between outward FDI and TFP are significantly positive, showing that lagged FDI positively affects productivity in those industries possessing comparative advantage. This result is robust when different measure of RCA is employed in column (4) through (6). These appear to be in accordance with our theoretical prediction presented in Proposition 2.

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[16] Navaretti and Venables (2004) find that domestic activities of multinationals are on average 17 percentage more productive than are domestic firms. But they use firm level data without considering competitiveness of industries, while our work is mostly focused on the role of comparative advantage of industry using industry level data. Thus the size of FDI premium may not be directly comparable. Using U.K. industry-level data, Driffield et al. (2009) show that the elasticity of the impact of outward FDI on productivity ranges between 0.024 and 0.04 depending on sector. They, however, also do not directly measure the effect of comparative advantage. In our model, the effect of FDI is smaller than that in Driffield et al. (2009), partly due to the cross country variation in the magnitude of the FDI effect on industry productivity, or due to the additional moderation effect of industry competiveness.

[17] We divide industries into two groups based on RCA index being 1 and above or not and estimated the effect of lagged outward FDI on industry productivity. We find that the coefficients of lagged FDI are positive and significant in both groups.

[Table 2] Comparative Advantage, Outward FDI and Productivity

Dependent variable: Log of TFP						
	(1)	(2)	(3)	(4)	(5)	(6)
	RCA_index	RCA_index	RCA_index	RCA_median	RCA_mean	RCA_dummy
lnFDI(t-1)		0.002**	0.001**	0.002**	0.002**	0.002**
		(0.0009)	(0.0008)	(0.0008)	(0.0009)	(0.001)
RCA(t-1)	0.004***	0.004***	0.004***	0.004***	0.003***	0.002*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
lnFDI*RCA(t-1)			0.002*	0.0004***	0.0002*	0.0002**
			(0.001)	(0.0001)	(0.0001)	(0.0001)
Industry fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.01	0.161	0.166	0.15	0.165	0.168
# of Observations	716	621	621	604	621	607

Notes: Robust standard errors are in parentheses. ***, **, and * indicate statistical significance at 1%, 5%, and 10% respectively. Natural log of TFP is the residual of the regression of the natural logarithm of real value added per labor on the logarithm of real capital stock per labor and the logarithm of the number of workers. All regressions include industry fixed effects. RCA median and mean dummies indicate whether the RCA index of a specific industry is above or below median, mean of whole industries in a certain year. RCA index dummy indicates whether RCA index of an industry exceeds 1 or not.

In sum, the above results from our model suggest that outward FDI in Korea has positive effects on industry productivity and this effect is mostly driven by industry competitiveness. Overall, this result is consistent with BRS (2007) in explaining access to foreign markets in the context of comparative advantage but diverges from their model because FDI is not modelled in their paper.

4.2. Robustness Checks

As discussed in previous chapters, we test the robustness of our results by resolving for potential endogeneity problem. To examine whether the relationship between outward FDI and industry productivity on one hand and the role of comparative advantage on the other found in the estimation of baseline model reflects the effect of FDI and the industry attributes, we obtain the system GMM estimates based on the model specification. The results are reported in Table 3. The time-lagged TFP coefficients are positive and statistically significant in all specifications reported in column (1) through (5) of Table 3. According to Roodman (2009), the estimated coefficient on the lagged dependent variable in system GMM should have a value less than unity in order to indicate convergence. The estimated coefficients on the lagged TFP lie between 0.816~0.965, which indicate that the steady-state assumption and the validity of instruments hold.

The impact of outward FDI on productivity is positive and statistically significant regardless of the way RCA index is measured. The coefficient of the industry competitiveness has positive and significant impact on productivity of domestic industries, except when RCA is measured as bivariate indicating whether it is above or below industry average. It is also shown that the coefficient of interaction term between outward FDI and industry competitiveness is positive and statistically significant, suggesting that the positive effect of outward FDI occurs more prominently in industries with comparative advantage. The size of the coefficient of the interaction term, however, varies depending on the model specification. In table 2, the coefficients of the interaction terms are smaller than those of the impact of FDI while they are same or larger in column (3) and (5) in table 3. Thus, the extent to which comparative advantage of industry plays role in the effect of FDI on productivity is not clear though there exists consistent and significantly positive role of industry competitiveness on the impact of FDI.

[Table 3] Comparative Advantage, Outward FDI and Productivity (System GMM)

Dependent variable: log of TFP					
	(1)	(2)	(3)	(4)	(5)
VARIABLES			RCA_median	RCA_mean	RCA_dummy
lnTFP(t-1)	0.816***	0.890***	0.965***	0.875***	0.762***
	(0.024)	(0.024)	(0.020)	(0.014)	(0.040)
lnFDI	0.0006***	0.0003***	0.0002***	0.0006***	0.0004***
	(0.0001)	(0.00005)	(0.00002)	(0.0001)	(0.0001)
RCA		0.002***	0.003***	0.0002	0.003***
		(0.0005)	(0.0003)	(0.0001)	(0.0008)
lnFDI×RCA			0.0002**	0.00013**	0.0007***
			(0.00009)	(0.00006)	(0.0002)
Year fixed effect	Yes	Yes	Yes	Yes	Yes
AR(1)	-3.23	-3.21	-3.59	-4.93	-4.48
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
AR(2)	1.50	1.23	1.13	1.28	0.71
(p-value)	(0.134)	(0.23)	(0.257)	(0.200)	(0.477)
Hansen (p-value)	0.998	0.997	0.818	0.195	0.772
Observations	580	580	580	555	580
Number of instruments	49	49	54	54	49

Notes: Standard errors are in parentheses.***, **, and * indicate statistical significance at 1%, 5%, and 10% respectively.

The coefficient of AR(1) has negative sign and statistically significant as expected. The insignificance of AR(2) tests suggest that there is no serial correlation between the lagged error term in differenced error term and the error term lagged two periods in lagged differenced error term. The *p*-value of Hansen test implies that there is no over-identifying restrictions problem. Thus, specification test do not reject the validity of the model specification. Finally, the numbers of instruments do not exceed the numbers of observations, which satisfy the rules of no weak instruments that can cause biased estimates.

Overall, the result from robustness check using system GMM confirms the estimation result of our baseline model and consistent with the main implication of our theoretical model, where industries with more multinational activities enjoy a higher level of productivity at home. It also supports our theoretical prediction that the FDI boosts performance of comparative advantage industries.

V. Conclusion

There seems to be a consensus on the argument that outward FDI has significant impact on activities in the home country, though the direction and magnitude of the impact vary across industries and countries over time. What is less known is the mechanism through which FDI affects productivity in domestic industries. In this paper, we develop a theoretical model which advances HMY's (2004) outward FDI model with heterogeneous, monopolistically competitive firms by introducing two sectors with comparative advantage and comparative disadvantage, and firm's intra-firm trade.

In the theoretical framework, we show that the increase in outward FDI raises aggregate productivity in both industries, but this productivity growth is more prominent in a comparative advantage industry. Two features in our model induce these phenomena above. First, in considering heterogeneous firms and FDI in the model, we show that relatively high productivity firms perform FDI with intra-firm exports, while low productivity firms serve only the domestic market. Second, as to comparative advantage industries, we show that the share of MNEs are relatively greater in a comparative advantage industry than in a comparative disadvantage industry so that the *ex ante* aggregate productivity in the former is relatively larger. From two features above, MNEs have more chance to enjoy greater profits from FDI and in turn, domestic producers are more likely to exit the market due to the decrease in the average price level and thus their revenue, i.e., the creative destruction of firms from FDI. In addition, this creative destruction of firms in response to the increase in outward FDI are more prominent in a comparative advantage industry. Hence the results imply that *ex ante* high average industry productivity triggered by firm self-selection enhances *ex post* average industry productivity during the increase in outward FDI, especially in a nation's comparative advantage industries.

We empirically estimate a simple model for productivity as a benchmark model followed by system GMM estimation methods for sensitivity analysis. Our empirical test find that there is a positive effect of outward FDI on domestic productivity and this effect is more likely to occur in those sectors with high competitiveness measured as export-based RCA. This result may be attributed to the complementary relationship between Korea's outward FDI and exports as well as intra-industry reallocation of firms in response to the increase in FDI. The theoretical analysis also shows that there are greater share of exports and outward FDI in a country's comparative advantage industry.

The empirical finding of this paper on the positive effect of outward FDI on industry-level performance is supported by the existing literature such as Desai et al. (2009), Hijzen et al. (2006), Fedrico and Minerva (2008), and Blomström et al. (1997). Another finding of this paper on the role of comparative advantage in FDI-performance linkage is in line with extant related literature. A recent theoretical prediction has been put forward by BRS (2007) which is an extension of Melitz (2003), and has considered comparative advantage as well as firm heterogeneity as a source of improvements in aggregate productivity and labor reallocation in response to trade liberalization. Given the complementary relationship between trade and outward FDI, the result of this paper can be interpreted in the context of interplay between industry competitiveness and MNE activities.

This paper has several limitation as well as contribution. First, in our model, we did not consider the case in which firms undertaking only exports and firms serving only domestic markets coexist. This is because the existence of the pure exporters can distract the main objective of the paper to examine the mechanism through which the FDI affects productivity. If there exists pure exporters, outward FDI will affect the average industry productivity through indirect effect on these exporters, which depends on whether exports and FDI are complements or substitutes. As taking into account the relationship between exports and FDI is beyond the scope of this paper, we rule out the possibility that some firms solely export and others invest abroad without exporting. Second, this paper employs static partial equilibrium model. Hence the paper does not consider any dynamic aspects in the mechanisms such as the changes in firms' exit and entry due to data limitations as well as difficulties of calculating explicit solutions. If dynamic aspects of the mechanism through which FDI affects productivity can be explored, we may obtain more thorough understanding on the joint role of FDI and comparative advantage of industries. We leave these issues for future research.

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Appendix I. Proofs of Propositions

Proposition 1.*Proof.*

In (20), P_i^H represents the aggregate price index with FDI barriers. If we consider the closed economy in (21), then we obtain

$$(P_i^H)^{CLOSED\ ECON} = \Omega (w_S^H)^{\beta_i} (w_U^H)^{1-\beta_i} (f_D)^{\frac{\lambda}{\gamma(\sigma-1)}} \quad \text{(A1)}$$

If the economy goes to costly FDI from autarky, then

$$(P_i^H)^{COSTLY\ FDI} = \Omega (w_S^H)^{\beta_i} (w_U^H)^{1-\beta_i} (f_D)^{\frac{\lambda}{\gamma(\sigma-1)}} \left(1 + \left(\frac{f_D}{f_O}\right)^{\frac{\lambda}{\sigma-1}} \frac{1}{\tau^{\gamma(1-\varphi)}} \left(\frac{(w_S^H)^{\beta_i} (w_U^H)^{1-\beta_i}}{(w_S^F)^{\beta_i} (w_U^F)^{1-\beta_i}} \right)^{\gamma\varphi} \left(\frac{P_i^F}{P_i^H} \right)^{\lambda} \right)^{-\frac{1}{\gamma}} \quad \text{(A2)}$$

where $(1+(\frac{f_D}{f_O})^{\frac{\lambda}{\sigma-1}} \frac{1}{\tau^{\gamma(1-\varphi)}} (\frac{(w_S^H)^{\beta_i} (w_U^H)^{1-\beta_i}}{(w_S^F)^{\beta_i} (w_U^F)^{1-\beta_i}})^{\gamma\varphi} (\frac{P_i^F}{P_i^H})^{\lambda})^{-\frac{1}{\gamma}} < 1$ as the second term in parenthesis is greater than zero. Then, $(P_i^H)^{COSTLY\ FDI} < (P_i^H)^{CLOSED\ ECON}$.

Also, if the economy goes to free FDI situation expressed by $\tau \to 1$ and $f_O \to f_D$, then

$$(P_i^H)^{FREE\ FDI} = \Omega (w_S^H)^{\beta_i} (w_U^H)^{1-\beta_i} (f_D)^{\frac{\lambda}{\gamma(\sigma-1)}} \left(1 + \left(\frac{(w_S^H)^{\beta_i} (w_U^H)^{1-\beta_i}}{(w_S^F)^{\beta_i} (w_U^F)^{1-\beta_i}} \right)^{\gamma\varphi} \left(\frac{P_i^F}{P_i^H} \right)^{\lambda} \right)^{-\frac{1}{\gamma}} \quad \text{(A3)}$$

Again, since $(\frac{(w_S^H)^{\beta_i} (w_U^H)^{1-\beta_i}}{(w_S^F)^{\beta_i} w_U^F)^{1-\beta_i}})^{\gamma\varphi} (\frac{P_i^F}{P_i^H})^{\lambda} > 0$, $(1+(\frac{(w_S^H)^{\beta_i} (w_U^H)^{1-\beta_i}}{(w_S^F)^{\beta_i} (w_U^F)^{1-\beta_i}})^{\gamma\varphi} (\frac{P_i^F}{P_i^H})^{\lambda})^{-\frac{1}{\gamma}} < 1$. From this, we obtain $(P_i^H)^{FREE\ FDI} < (P_i^H)^{COSTLY\ FDI}$. Synthetically, $(P_i^H)^{FREE\ FDI} <$ $(P_i^H)^{COSTLY\ FDI}$ $< (P_i^H)^{CLOSED\ ECON}$

In this respect, the domestic aggregate price index decreases when the economy increases its outward FDI in response to the decrease in τ and/or f_O in (18), perceiving that P_i^H is monotonically increasing in τ and/or f_O. Finally, $\tilde{\theta}_i^H$, will increase in response to the decrease in P_i^H in (23), implying that the domestic average productivity increases when the economy goes to free FDI situation and increases its outward FDI. □

Proposition 2.*Proof.*

From (20), we define the relative aggregate price of industry 1 in terms of industry 2, $\frac{P_1^H}{P_2^H}$, in home as follows:

$$\frac{P_1^H}{P_2^H}=\left(\frac{w_S^H}{w_U^H}\right)^{\beta_1-\beta_2}\left(\frac{\left(\frac{1}{f_D}\right)^{\frac{\lambda}{\sigma-1}}+\left(\frac{1}{f_O}\right)^{\frac{\lambda}{\sigma-1}}\frac{1}{\tau^{\gamma(1-\varphi)}}\left(\frac{(w_S^H)^{\beta_2}(w_U^H)^{1-\beta_2}}{(w_S^F)^{\beta_2}(w_U^F)^{1-\beta_2}}\right)^{\gamma\varphi}\left(\frac{P_2^F}{P_2^H}\right)^{\lambda}}{\left(\frac{1}{f_D}\right)^{\frac{\lambda}{\sigma-1}}+\left(\frac{1}{f_O}\right)^{\frac{\lambda}{\sigma-1}}\frac{1}{\tau^{\gamma(1-\varphi)}}\left(\frac{(w_S^H)^{\beta_1}(w_U^H)^{1-\beta_1}}{(w_S^F)^{\beta_1}(w_U^F)^{1-\beta_1}}\right)^{\gamma\varphi}\left(\frac{P_1^F}{P_1^H}\right)^{\lambda}}\right)^{\gamma} \tag{A4}$$

Under the closed economy, we obtain (A5) from (A4):

$$\frac{P_1^H}{P_2^H}=\left(\frac{w_S^H}{w_U^H}\right)^{\beta_1-\beta_2} \tag{A5}$$

From the assumption of factor abundance in each country, $\frac{w_S^H}{w_U^H}<\frac{w_S^F}{w_U^F}$, this implies the lower relative average price level for comparative advantage industry in each country, $\frac{P_1^H}{P_2^H}<\frac{P_1^F}{P_2^F}$, in the closed economy. By the Heckscher-Ohlin theorem, a country specializes in producing its comparative advantage good when opening the economy. In home country, the relative wage for skilled labor, $\frac{w_S^H}{w_U^H}$, will increase when the economy moves from autarky to costly FDI situation because its comparative advantage industry, sector 1, is skilled labor intensive and so there is greater demand for skilled labor than that for unskilled labor. In this process, two relative wage rates from each country are converging to be equal each other.

Meanwhile, (A5) implies that $\frac{P_1^H}{P_2^H}$ is increasing in $\frac{(w_S^H)}{(w_U^H)}$ (i.e., $\frac{\partial(\frac{P_1^H}{P_2^H})}{\partial(\frac{w_S^H}{w_U^H})}>0$), but at decreasing rate (i.e., $\frac{\partial^2(\frac{P_1^H}{P_2^H})}{\partial(\frac{w_S^H}{w_U^H})^2}<0$), where 1 is relatively skilled-labor intensive (i.e., $\beta_1-\beta_2>0$). In this respect, we conclude that $\frac{P_1^H}{P_2^H}<\frac{P_1^F}{P_2^F}$ at any case (i.e., closed economy or costly FDI or free FDI).

From (17) and (18), the relative threshold of domestic production in terms of overseas is

$$\frac{\bar{\theta}_{iD}^H}{\bar{\theta}_{iO}^H}=\tau^{1-\varphi}\frac{P_i^F}{P_i^H}\left(\frac{f_D}{f_O}\right)^{\frac{1}{\sigma-1}}\left(\frac{(w_S^H)^{\beta_i}(w_U^H)^{1-\beta_i}}{(w_S^F)^{\beta_i}(w_U^F)^{1-\beta_i}}\right)^{\varphi} \tag{A6}$$

Then we obtain the following equation to compare (A6) across industries within a country:

$$\frac{\bar{\theta}_{1D}^H\bar{\theta}_{2O}^H}{\bar{\theta}_{1O}^H\bar{\theta}_{2D}^H}=\frac{P_1^F P_2^H}{P_1^H P_2^F}\left(\left(\frac{w_S^H w_U^F}{w_U^H w_S^F}\right)^{\beta_1-\beta_2}\right)^{\varphi} \tag{A7}$$

If $\varphi = 0$ which implies that a firm produces only in home country and exports some products to foreign country, then $\frac{\bar{\theta}_{1D}^H \bar{\theta}_{2O}^H}{\bar{\theta}_{1O}^H \bar{\theta}_{2D}^H} = \frac{P_1^F P_2^H}{P_1^H P_2^F}$ from (A7) and so $\frac{\bar{\theta}_{1D}^H}{\bar{\theta}_{1O}^H} > \frac{\bar{\theta}_{2D}^H}{\bar{\theta}_{2O}^H}$ as $\frac{P_1^H}{P_2^H} < \frac{P_1^F}{P_2^F}$ at any case. This result reverts to BRS (2007).

If $\varphi = 1$ which implies that there are no exports, then $\frac{\bar{\theta}_{1D}^H \bar{\theta}_{2O}^H}{\bar{\theta}_{1O}^H \bar{\theta}_{2D}^H} = \frac{P_1^F P_2^H}{P_1^H P_2^F} (\frac{w_S^H w_U^F}{w_U^H w_S^F})^{\beta_1 - \beta_2}$. Given $\frac{P_1^H}{P_2^H} = (\frac{w_S^H}{w_U^H})^{\beta_1 - \beta_2}$ and $\frac{P_1^F}{P_2^F} = (\frac{w_S^F}{w_U^F})^{\beta_1 - \beta_2}$ in the closed economy, $\frac{\partial^2 (\frac{P_1^H}{P_2^H})}{\partial (\frac{w_S^H}{w_U^H})^2} < 0$ from (A5), and the conditions for factor abundance $\frac{w_S^H}{w_U^H} < \frac{w_S^F}{w_U^F}$ and $\frac{P_1^H}{P_2^H} < \frac{P_1^F}{P_2^F}$, the difference between $\frac{w_S^H}{w_U^H}$ and $\frac{w_S^F}{w_U^F}$ is less than that between $\frac{P_1^H}{P_2^H}$ and $\frac{P_1^F}{P_2^F}$ under costly FDI situation. Hence, we obtain $\frac{\bar{\theta}_{1D}^H}{\bar{\theta}_{1O}^H} > \frac{\bar{\theta}_{2D}^H}{\bar{\theta}_{2O}^H}$ under costly FDI situation. Also, if the economy moves to free FDI from costly FDI situations, the difference between $\frac{w_S^H}{w_U^H}$ and $\frac{w_S^F}{w_U^F}$ is more likely to be less than that between $\frac{P_1^H}{P_2^H}$ and $\frac{P_1^F}{P_2^F}$, implying that $\frac{\bar{\theta}_{1D}^H}{\bar{\theta}_{1O}^H}$ is more likely to be greater than $\frac{\bar{\theta}_{2D}^H}{\bar{\theta}_{2O}^H}$ (i.e., $\frac{\bar{\theta}_{1D}^H}{\bar{\theta}_{1O}^H} > \frac{\bar{\theta}_{2D}^H}{\bar{\theta}_{2O}^H}$).

For $0 < \varphi < 1$, we can obtain the same conclusion as the situation with $\varphi = 1$ because the value of $(\frac{w_S^H w_U^F}{w_U^H w_S^F})^{\beta_1 - \beta_2}$ is maximum when $\varphi = 1$.

In this respect, we conclude that $\frac{\bar{\theta}_{1D}^H}{\bar{\theta}_{1O}^H} > \frac{\bar{\theta}_{2D}^H}{\bar{\theta}_{2O}^H}$, regardless of φ, and that the difference between $\frac{\bar{\theta}_{1D}^H}{\bar{\theta}_{1O}^H}$ and $\frac{\bar{\theta}_{2D}^H}{\bar{\theta}_{2O}^H}$ is being greater as the economy moves from the closed economy to costly FDI, and also from costly FDI to free FDI. Meanwhile, higher relative $\bar{\theta}_{iD}^H$ in terms of $\bar{\theta}_{iO}^H$ implies higher average productivity from (22) and so $\tilde{\theta}_1^H > \tilde{\theta}_2^H$ in costly FDI situation. Hence $\frac{\tilde{\theta}_1^H}{\tilde{\theta}_2^H}$ is being greater as $\frac{\bar{\theta}_{1D}^H}{\bar{\theta}_{1O}^H}$ is more likely to be greater than $\frac{\bar{\theta}_{2D}^H}{\bar{\theta}_{2O}^H}$ if the economy moves from costly FDI to free FDI. □

Appendix II. Correlation Matrix

	lnFDI	lnTFP	RCA dummy	RCA median dummy
lnFDI				
lnTFP	0.1746			
RCA dummy	0.2596	0.0645		
RCA median dummy	0.3016	0.0581	0.6548	
RCA mean dummy	0.3186	0.0688	0.9179	0.6282

Note: RCA median and mean dummies indicate whether the RCA index of a specific industry is above or below median, mean of whole industries in a certain year. RCA index dummy indicates whether RCA index of an industry exceeds 1 or not. Natural log of TFP is residual of regression of on log of real capital per labor, labor on the log of real value added per labor.

Appendix III. RCA and Industry Characteristics in 2008

Industries	lnFDI	RCA	lnTFP
Mining of Coal	13.282	0.002	0.090
Mining of Iron Ores	9.861	0.000	N/A
Mining of Non-ferrous Metal Ores	12.852	0.090	N/A
Quarrying of Kaolin and Other Clays	8.268	0.039	0.059
Slaughtering of Livestock, Processing, Preserving of Meat, Meat Products and Fruit and vegetables	12.686	0.132	-0.073
Manufacture of Dairy Products and edible Ice Cakes	10.135	0.015	0.055
Manufacture of Grain Mill Products, Starches and Starch Products	10.294	0.101	-0.003
Manufacture of Other Food Products	12.155	0.282	-0.088
Manufacture of Beverages	10.245	0.128	0.120
Manufacture of Tobacco Products	10.454	0.710	-0.481
Textiles	11.811	1.024	-0.028
Wearing apparel, Clothing Accessories	12.376	0.469	0.372
Fur Articles	7.857	0.112	-0.305
Tanning and Dressing of Leather , Manufacture of Luggage	10.819	0.528	0.184
Footwear	10.434	0.193	0.305
Sawmilling and Planing of Wood	9.262	0.008	0.030
Manufacture of Wood Products of Wood and Cork ; Except Furniture	8.906	0.028	0.086
Furnitures	9.580	0.166	0.063
Pulp, Paper and Paper Products	10.095	0.462	-0.093
Printing and Service Activities Related to Printing	7.993	0.179	-0.045
Coke and Briquettes	9.861	0.007	N/A
Refined Petroleum Products	9.855	1.654	0.414
Basic Chemicals	12.376	1.767	0.103
Man-Made Fibers	7.702	2.943	0.070
Other Chemical Products	12.366	0.296	0.057
Rubber Products	12.088	1.112	-0.036
Plastic Products	11.085	0.788	-0.047
Glass and Glass Products	10.901	0.425	0.060
Other Non-metallic Mineral Products	11.429	0.304	0.017
Basic Iron and Steel	13.097	1.610	0.185
Cast of Metals	10.618	N/A	0.161
Basic Precious and Non-ferrous Metals	11.231	0.733	0.208
Structural Metal Products, Tanks, Reservoirs and Steam Generators	10.020	1.318	0.105
Other Metal Products; Metal Working Service Activities	12.009	0.741	-0.009
Electronic Components	13.539	1.482	-0.108
Telecommunication and Broadcasting Apparatuses	11.286	3.533	0.434
Electronic Video and Audio Equipment	12.026	1.424	-0.285
Medical Appliances and Instruments	10.862	0.345	-0.035
Photographic Equipment and Other Optical Instruments	12.302	5.566	0.018
Watches, Clocks and its Parts	N/A	0.095	-0.061
Primary Cells and Batteries and Accumulators	8.361	2.817	0.549
Electric Lamps and Bulbs	9.598	0.594	0.070

Domestic Appliances	8.728	1.089	0.038
Other Electrical Equipment	12.331	1.040	0.065
General Purpose Machinery	12.193	0.784	0.081
Motor Vehicles and Engines for Motor Vehicles	13.548	1.437	0.036
Parts and Accessories for Motor Vehicles and Engines	13.124	1.442	0.003
Building of Ships and Boats	13.671	10.619	0.060
Aircraft, Spacecraft and its Parts	5.986	0.122	-0.080
Other Transport Equipment	9.711	0.110	0.116
Other Manufacturing n.e.c.	11.913	0.201	-0.063

Note: RCA index is calculated based on equation (29).

Appendix IV. The Impact of FDI on Industry Size, Wage and Firm Exit

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variables	Size	Size	Wage	Wage	Number of firms	Number of firms
lnFDI(t-1)	0.035***	0.032**	0.029***	0.024*	0.022*	0.024***
	(0.012)	(0.015)	(0.009)	(0.012)	(0.011)	(0.008)
RCA(t-1)	0.210***	0.211***	0.194***	0.195***	0.101***	0.100***
	(0.055)	(0.054)	(0.049)	(0.048)	(0.036)	(0.036)
lnFDI*RCA(t-1)		0.025		0.035	0.014	
		(0.040)		(0.031)	(0.034)	
Industry Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.984	0.984	0.987	0.987	0.993	0.993
Observations	411	411	411	411	422	422

Notes: Robust standard errors are in parentheses. ***, **, and * indicate statistical significance at 1%, 5%, and 10% respectively. All regressions include industry fixed effects. RCA indicates whether the RCA index of a specific industry is above or below median.